

REMARKS

Amendments

Claims 1, 21, 45, 48 and 51 have been amended to specify the catalyst employed in the claimed selective oxidation process to consist essentially of a catalytically active mixture of rhodium, iridium, zirconium and cerium. These amendments are supported by Example 1, Catalysts 1 and 6; Example 4, Catalyst 7, and Example 6, Catalyst 8, on pages 7-14 of the present specification.

Claims 11 and 85 have been amended to recite that the catalyst carrier comprising zirconia stabilized with yttria is coated with zirconia paint comprising zirconium oxide stabilized with CaO. These amendments are supported by Example 1, Catalysts 1, 3 and 6; Example 4, Catalyst 7 and Example 6, Catalyst 8, on pages 7-14 of the present application.

Claim 16 has been amended to recite the catalyst further consists essentially of certain specified performance-enhancing inorganic metal cations, as disclosed on page 5 of the specification, lines 14-19. Its dependency was also changed to claim 46.

Claim 24 has been amended to add the further limitation that the feed mixture have an oxygen-to-carbon ratio of below 0.10, as disclosed on page 6 of the present specification, lines 15-16.

Claim 25 has been amended to recite the catalyst employed in the claimed selective oxidation process consist essentially of iridium supported on alumina stabilized with magnesium oxide. These amendments are supported by Example 1, Catalyst 5, on page 8 of the present specification.

Claim 30 has been amended to recite that the sulfur compound selectively oxidized is a heterocyclic sulfur compound, which are known to be very difficult to selectively oxidize, as disclosed on page 4 of the present specification, lines 4-9.

Claim 38 has been amended to recite specific heterocyclic sulfur compounds which may present in the hydrocarbonaceous feedstock, as disclosed on page 4 of the present specification, lines 4-9.

Claims 46, 49 and 52 have been amended to recite that the non-refractory oxide bulk material employed as a catalyst support have an oxidizing surface selected from the group consisting of alumina and zirconia, which is supported by the disclosure on page 4 of the specification, line 33 to page 4, line 3.

The amendments to claims 65 and 75 merely change their dependency.

The amendment to claim 86 was necessitated by the amendment to claim 51, from which it indirectly depends, specifying the catalyst consists essentially of a mixture of catalytically active metals.

Claim Rejections – 35 USC § 103

I. The Rejection of Claims 1-2, 9, 11-21 and 24 under 35 U.S.C. §103(a) as Being Unpatentable over Frame (US 3,978,137) in View of Yoo (US 3,945,914), Mahadev (WO 92/20621), and Mackrodt (US 5,137,682), to the extent it applies to the Amended Claims, is Respectfully Traversed

I. (a) The Presently Claimed Invention

The presently claimed process relates to the catalytic selective oxidation of sulfur compounds, including difficult to treat sulfur compounds such as thiophenes, contained in a hydrocarbonaceous feedstock. The “selective oxidation of sulfur compounds” is defined on page 3, lines 15-19 of the present application to mean the oxidation of sulfur compounds to sulfur dioxide, with no or minimal oxidation of the non-sulfur containing hydrocarbonaceous compounds. This important feature of the present process can be accomplished by contacting a gaseous feed mixture of the hydrocarbonaceous feedstock and a molecular-oxygen containing gas in the presence of a particular defined catalyst under particular defined conditions, including a temperature of at the most 500 °C and an oxygen-to-carbon ratio in the feed mixture of below 0.15, preferably below 0.10.

The catalyst employed in the process of the invention is specified to consist essentially of a catalytically active Group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof. The Group VIII noble metal may be used alone or in mixtures with performance enhancing inorganic metal cations selected from Al Mg, Zr, Ti, La, Hf, Si, Ba and Ce. Claims 1, 21, 45, 48 and 51 have been amended to recite specific mixtures of catalytically active metals which were successfully employed in the various examples in the specification, and which were found to have excellent selectivity for oxidizing sulfur compounds, including difficult to remove heterocyclic sulfur compounds such as thiophenes, without oxidizing hydrocarbonaceous compounds.

The catalysts employed in the present selective oxidation process are supported on a catalyst carrier, typically in the form of solid particles, and having an oxidizing surface. By an

“oxidizing surface” is meant a surface that is able to activate molecular oxygen (see page 4 of specification, lines 21-25). Preferred catalyst carriers include stabilized or partially stabilized zirconia, ceria, yttria, silica, alumina, titania and combinations, with a catalyst carrier comprising zirconia stabilized or partially stabilized with yttria being most preferred. The catalyst carrier may also comprise a non-refractory bulk oxide material having an oxidizing surface, such as a Fe, Cr and Al containing bulk material with an alumina or zirconia oxidizing surface layer (see page 4 of the present specification, line 32 to page 5, line 4. These types of bulk oxide catalyst carriers are employed in the selective oxidation process recited in amended claims 46, 49 and 52.

Some of the catalysts of the invention were coated with a zirconia paint comprising zirconium oxide stabilized with CaO, which subject matter is claimed in amended claims 11 and 85.

The specific limitations being relied to distinguish the amended claims over the cited references include: A process for the selective oxidation of a sulfur compounds, including difficult to remove heterocyclic sulfur compounds such as thiophenes, contained in a hydrocarbonaceous feedstock to sulfur dioxide, with no or minimal oxidation of the non-sulfur containing hydrocarbonaceous compounds, using a catalyst which consists essentially of a catalytically active group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof, or a catalytically active mixture of rhodium and/or iridium with performance enhancing metal ions zirconium and cerium, as recited in amended claims 1, 21, 45, 48 and 51, at a concentration in the range of from 0.02 to 10% by weight, wherein a feed mixture of the hydrocarbonaceous feedstock and a molecular-oxygen containing gas is contacted with the catalyst at a temperature of at the most 500 °C, and the feed mixture has an oxygen-to-carbon ratio below 0.15, preferably below 0.10. Other features recited in the amended claims include the use of a catalyst carrier comprising zirconia stabilized with yttria and coated with a zirconia paint comprising zirconium oxide stabilized with CaO. As discussed below, none of the cited references alone or in combination, teach or reasonably suggest the above-mentioned combination of limitations, including the particular defined catalyst and catalyst carrier employed in the present process, and the oxygen-to-carbon ratio in the feed mixture, all of which are necessary to achieving the desired selective oxidation of sulfur compounds in a hydrocarbonaceous feedstock to sulfur dioxide, with no or minimal oxidation of the non-sulfur containing hydrocarbonaceous compounds.

I. (b) The Sulfur Compound Oxidation Process Disclosed in the Primary Reference Employs a Different Catalyst System than the Catalyst Employed in the Selective Oxidation Process Recited in the Present Claims

The primary reference, Frame (US 3,978,137) (hereafter “Frame”), discloses a process for the oxidation of sulfur-containing compounds which comprises treatment of the sulfur-containing compounds with an oxygen-containing gas in a medium possessing a pH in the range of 8 to a pH of 14 in the presence of a two component catalyst system comprising a Group VIIB metal phthalocyanine and a Group VIII metal phthalocyanine at oxidation conditions, and recovering the resultant oxidized sulfur-containing compound (col. 2, lines 32-41).

In column 3, lines 51-54, it is stated that: “In the pure essence of this invention the catalyst system for the oxidation of sulfur-containing compounds comprises a Group VIIB metal phthalocyanine and a Group VIII metal phthalocyanine two-component system.” (emphasis added). Frame goes on to teach that the catalyst system may be present in a range of from about 6 parts per Group VIIB metal phthalocyanine to about 1 part Group VIIB metal phthalocyanine per part Group VIII metal phthalocyanine.” (col. 3, lines 55-59). This indicates that a major proportion of the two-component catalyst system of Frame must be a Group VIIB metal phthalocyanine, i.e., from 6 to 1 parts Group VIIB metal phthalocyanine per part of Group VIII metal phthalocyanine. Expressed in percentages, the proportions would be from 85.7 to 50 % Group VIIB metal phthalocyanine to 14.3 to 50 % Group VIII metal phthalocyanine.

The importance of a Group VIIB metal phthalocyanine being used in conjunction with the Group VIII metal phthalocyanine is also emphasized in col. 4, lines 32-36, of Frame, wherein it is stated: “It should again be noted that the catalyst system comprises a two-component system whereby it is necessary for the Group VIIB metal phthalocyanine and the Group VIII metal phthalocyanine to be present in conjunction with one another.” (emphasis added).

In order to clearly distinguish the catalyst employed in the present process from the two-component Group VIIB metal phthalocyanine and a Group VIII metal phthalocyanine catalyst system disclosed in Frame, Applicants amended the present claims to read “wherein said catalyst consists essentially of a catalytically active group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof”. The transitional phrase “consisting essentially of” functions to exclude a two component catalyst system such as that disclosed in Frame, which contains a major proportion of a Group VIIB metal

phthalocyanine as an essential component. As discussed Sections I.(c) and I.(d), below, the basic and novel characteristics of the presently claimed selective oxidation process are disclosed in the present specification, and would be materially altered if the two component catalyst system disclosed in Frame were utilized in the present process. Therefore, it would be inappropriate (and clear error) for the Examiner to construe the transitional phrase “consisting essentially of” as “comprising” in the present circumstances. Accordingly, it is respectfully requested that the Examiner reconsider his position in this regard.

I. (c) The transitional phrase “Consisting Essentially of” Should Not be Construed as “Comprising” in Rejecting the Present Claims. The Board Decision Rendered August 31, 2009 Does Not Support the Examiner’s Construction of “Consisting Essentially of” as “Comprising”.

The Examiner indicates on page 4 of the subject Office action, that for the purposes of searching and applying the prior art, he is treating the transitional phrase “consisting essentially of” as if it is equivalent to the term “comprising” in the absence of a clear indication of the basic and novel characteristics of the invention. However, Applicants’ specification, clearly presents the basic and novel characteristics of the inventive process. Therefore, the examiner must give the transitional phrase “consisting essentially of” its proper limiting function.

The basic and novel characteristics of the presently claimed process include the use of a catalyst capable of selectively oxidizing sulfur compounds in a hydrocarbonaceous feedstock directly to sulfur dioxide, with no or minimal oxidation of the non-sulfur containing hydrocarbonaceous compounds. The catalyst employed in the claimed selective oxidation process is specified to consist essentially of a catalytically active group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof at a concentration in the range of from 0.02 to 10% by weight, based on the total weight of the catalyst, supported on a catalyst carrier comprising zirconia that is stabilized or partially stabilized with yttria. The selective oxidation of the sulfur compounds in the hydrocarbonaceous feedstock directly to sulfur dioxide can be accomplished using the presently claimed process, without the need to adjust the pH of the contacting medium, or the need to add any additional materials.

Extensive details concerning the catalyst employed in the present inventive process, and concerning a comparative catalyst, are presented in Example 1. See pages 7-10 of the present specification. As described in Example 1, the inventive catalyst includes a support particle of

zirconia that is partially stabilized with yttria (Y-PSZ). The support particles may be painted with a zirconia paint and impregnated with at least one or more of either rhodium, iridium, zirconium, or cerium. Presented in Table 1 is performance data for the inventive catalyst and for the comparison catalyst. The data show that the inventive catalyst provides for a higher H₂S conversion for a given reaction temperature than does the comparison catalyst, and the selectivity is significantly different as well. (See Table 1 on page 10 of the present specification). The specification also suggests that the catalyst provides for a lower reaction temperature for carrying out the oxidation of sulfur compounds, and that at these lower temperatures the oxidation of the sulfur compounds takes preference over the oxidation of hydrocarbons. See page 5 of the present specification, lines 20-26).

Therefore, the Examiner's construction of the transitional phrase "consisting essentially of" as "comprising" is incorrect in that the basic and novel characteristics of the invention are clearly indicated in the specification and clearly distinguishes the presently claimed process from the process of Frame which employs a two-component metal phthalocyanine catalyst system that must be used in a medium having a pH of from 8 to a pH of 14, and only oxidizes sulfur compounds such as hydrogen sulfide to sulfur and mercaptans to disulfides, instead of oxidizing the sulfur compounds to sulfur dioxide. (This latter aspect is discussed in greater detail in Section I.(e), below.)

The Board's decision of August 31, 2009 does not support the Examiner's construction of "consisting essentially of" the same as "comprising" as stated in paragraph 27, page 18 of the subject Office action. The claim on which the Board rendered its decision did not contain the transitional phrase "consisting essentially of", but instead contained the limitation that the claimed catalyst "comprises a catalytically active group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof". The Board found that the term "comprises" was open and did not exclude additional components, such as the presence of Group VII phthalocyanines as part of the catalyst system. It is well established that the transitional phrase "consisting essentially of" is closed and would exclude other essential components such as the Group VII phthalocyanines of Frame's catalyst system. Applicants are confident that had the claims on appeal contained the closed term "consisting essentially of" instead of the open term "comprising", the Board would have found the claims patentable over Frame. There simply is nothing in the Board's opinion that supports the construction of "consisting

essentially of” to be the same as “comprising”. These terms have well established different legal meanings.

When the term “consisting essentially of” is given its proper legal meaning, as required by the present circumstances, claims 1-2, 9, 11-21 are clearly patentable over Frame, alone or in combination with the additional references cited, i.e., Yoo et al (US 3,945,914), Mahadev et al (WO 92/20621) and Mackrodt (US 5,978,137), each which are discussed in the following sections.

I. (d) The Sulfur Compound Oxidation Process Disclosed in Frame Requires an Additional Condition and an Additional Material Not Required in the Selective Oxidation Process Recited in the Present Claims

The process for the oxidation of sulfur compounds disclosed in Frame is taught to be effected in a medium possessing a pH in the range of from about a pH of 8 to about a pH of 14 (col. 4, lines 66-68). In order to meet this pH requirement, the medium which supplies the pH will comprise an alkaline material such as sodium hydroxide, potassium hydroxide, lithium hydroxide, rubidium hydroxide, cesium hydroxide, barium hydroxide, etc. (col. 4, line 68 to col. 5, line 18). Note that even if the two-component catalyst is dispersed on an inert support, it is still important that the treatment medium possess a pH of from about 8 to about 14 (col. 5, lines 27-35).

As shown by the examples in the Applicants’ specification, the present selective oxidation process utilizing the catalyst recited in the present claims, does not require a medium having a pH of from about 8 to about 14, and does not require the addition of an alkaline material.

Applicants recognize that the present claims do not expressly exclude operating at a pH of from 8 to a pH of 14, or exclude adding an alkaline material. However, the fact that Frame’s oxidation process requires a medium having pH of from 8 to 14 and requires the addition of an alkaline material, while Applicants’ process does not, is believed to be relevant to the issue of obviousness, in that it demonstrates a clear advantage for Applicants’ process. Even more importantly, it further demonstrates the significant differences between the respective processes.

In order to modify the process of Frame to arrive at Applicants’ selective oxidation process, one skilled in the art would have to change the catalyst system from a two-component system, including a major amount of Group VIIB metal phthalocyanine, to a single component system, contrary to Frame’s teaching that the two components must be used in conjunction. In addition, one skilled in the art would have to modify the severity of the oxidation conditions to

produce sulfur dioxide, instead of the sulfur and disulfides oxidations products produced by the process disclosed in Frame. Furthermore, one skilled in the art would have to disregard the clear teachings in Frame that the catalyst system must be used in a medium having a pH of from about 8 to about 14, which is accomplished by adding an alkaline material to the medium. Applicants respectfully submit that making these extensive and unobvious changes, which are contrary to the teachings of the Frame reference, is not within the routine skill and knowledge of one of ordinary skill in the art. Rather it is strong evidence of an invention.

While the Board in their August 31, 2009, decision did not find a somewhat similar argument persuasive, their finding was based in large part on the fact the previous claims contained the open ended “comprising” language. It is respectfully submitted the Board would have found the argument persuasive had the claims on appeal contained the close ended “consisting essentially of” transitional phrase.

I. (e) The Sulfur Compound Oxidation Process Disclosed in the Primary Reference Does Not Oxidize Sulfur Compounds to Sulfur Dioxide as Required by the Present Claims. Frame Does Not Disclose the “Exact Oxidation Conditions” Used in Present Process

Another important distinction between the presently claimed process and the oxidation process in Frame, is that the sulfur compounds in Frame are not selectively oxidized to sulfur dioxide, as required by the present claims. Instead, the sulfur compounds in Frame are oxidized to elemental sulfur in the case of hydrogen sulfide, or disulfides in the case of mercaptans. See the disclosure in col. 2, lines 9-24, of Frame wherein it is taught that the utility of the disclosed invention is that sulfur, the resultant oxidation product of hydrogen sulfide, can be used in the chemical industry, while various disulfides, which are separated and recovered subsequent to the oxidation of mercaptan compounds, can be selectively reduced back to mercaptans for use in natural gas for safety purposes.

Frame does not disclose “the exact same conditions as are used in the claimed process” as stated in paragraph 30, page 19 of the subject Office action. The process in Frame differs in at least two important respects from Applicants’ process. First, while the catalyst in Frame contains a Group VIII noble metal, the overall two component Group VIIB metal and Group VIII metal phthalocyanine catalyst system in Frame is very different from the supported group VIII noble

metal catalyst employed by Applicants. Second, Applicants' selective oxidation process uses a feed mixture having a specified oxygen-to-carbon ratio. Temperature and pressure are not the only process parameters that determine whether sulfur or sulfur dioxide is produced, or to what extent hydrocarbons are oxidized. The overall catalyst system employed and other conditions such as oxygen-to-carbon ratios also determine whether sulfur or sulfur dioxide is produced or whether hydrocarbons are oxidized. Thus, the statements made in paragraph 30 of the subject Office action that some level of sulfur oxide must inherently be produced in the process of Frame, or that Frame must necessarily inherently proceed with no or minimal oxidation, are based on speculation, rather than on fact, since all of the oxidation conditions are not same.

I. (f) Yoo et al (US 3,945,914)(hereafter "Yoo")

Yoo teaches a two-step process including a first step involving the oxidation of sulfur contained in a hydrocarbon material with an oxidant, optionally, in the presence of a metal-containing catalyst, (col. 2, lines 46-63), followed by contacting the oxidized sulfur-containing hydrocarbon material with a metal-containing compound under certain temperature conditions so as to form a metal-sulfur-containing compound. (col. 1, lines 50-61; and col. 7, lines 10-30). The preferred catalyst metals for the optional oxidation catalyst are Group IVB, Group VB, and Group VIB metals. (col. 4, lines 7-10). There is no disclosure in Yoo of a catalyst based on a Group VIII noble metal. Therefore, Yoo is even less relevant than Frame in this regard, since Frame at least discloses a two component catalyst system which includes a Group VIII metal phthalocyanine as a minor component.

Yoo does teach that the concentration of oxidant is usually dependent upon the amount of sulfur present in the hydrocarbon material as stated on page 5 of the subject Office action. It is noted that the preferred oxidants employed by Yoo are organic peroxides, organic hydroperoxides, organic peracids and hydrogen peroxide (see col. 3, lines 13 to col. 4, line 6), while a molecular-oxygen containing gas is employed in Applicants' process.

In paragraph 31 of the subject Office action it is implied that by pointing out that Yoo does not disclose a noble metal based catalyst it appears Applicants are attacking references individually. Applicants realize that the Examiner is relying on Frame for the disclosure of an oxidation catalyst containing a Group VIII noble metal, albeit in an entirely different system. However, it is relevant that the catalyst in Yoo is not based on a Group VIII noble metal, since

the Examiner is using Yoo to make certain calculations and analogies which are not accurate or appropriate when substantially different catalyst systems are involved.

I. (g) Neither Frame nor Yoo Teach or Reasonably Suggest a Gaseous Feed Mixture Having the Oxygen-to-Carbon Ratios Recited in the Present Claims

On page 4 of the subject Office action the Examiner acknowledges that Frame does not explicitly disclose mixing a gaseous hydrocarbonaceous feedstock with an oxygen-containing gas to produce a feed mixture having an oxygen-carbon ratio of below 0.10. As discussed below, the limitations in the claims regarding the oxygen-to-carbon ratios of the gaseous feed mixture to the present process are not taught or reasonably suggested by Frame, Yoo, or any of the other cited references.

In an effort to overcome the deficiency of Frame in not teaching the oxygen-to-carbon ratios recited in the present claims, the Examiner, in the paragraph bridging pages 4 and 5 of the subject Office action, takes the position that Yoo teaches a feed mixture having an oxygen-to-carbon ratio of approximately 0.005 based on certain calculations and assumptions made by the Examiner. While this calculated value is within the limitation recited in the present claims, Applicants respectfully submit that the Examiner's calculated value is not reflective of the overall teachings of Yoo, appears to be based in part on an incorrect assumption as discussed below.

The basis for the Examiner's calculation is set forth on page 4 of the subject Office action and reads as follows:

“In addition, Yoo explains that a hydrocarbon feed mixture of oxygen-containing has an oxygen-sulfur ratio of about 0.5 with the sulfur content of the feed being about 1 wt%. Because hydrocarbons comprise carbon atoms, 99% of the feed would contain carbon atoms. Thus, the oxygen-carbon ratio would be approximately 0.005 (see Yoo column 1, lines 64-68; and column 2, lines 43-63.”

What Yoo actually discloses in col. 1, lines 64-68, is that, in general, the sulfur content of the hydrocarbon materials may be greater than 1 % by weight. The hydrocarbon material employed in Examples I to III, in col. 9 of Yoo, had a sulfur content of 1.73 wt%. (See col. 9, line 22).

What Yoo actually discloses col. 2, lines 43-63, is that the mole ratio of oxidant to sulfur contained in the hydrocarbon material is from about 0.5 to about 10 atoms of active oxygen per atom of sulfur, preferably from about 1 to about 8 atoms of active oxygen per atom of sulfur, and more preferably from about 1.5 to about 4.0 atoms of active oxygen per atom of sulfur. The ratio of oxidant to sulfur in Examples I to III of Yoo was 3.0 moles tertiary butyl hydroperoxide per mole of sulfur (col. 9, lines 49-51). Yoo did not employ a molecular oxygen-containing gas in any of the Examples. Since Yoo teaches a range of active oxygen atoms to sulfur of 0.5 to 10, and also teaches that the hydrocarbon material generally has a sulfur content greater than 1 wt%, it is unclear why the Examiner chose the specific oxygen to sulfur ratio of 0.5 and a sulfur content of 1 wt% for his calculation.

Applicants are also unclear as to the basis for the statement on page 4 of the subject Office Action that: "Because hydrocarbons comprise carbon atoms, 99% of the feed would contain carbon atoms." Since hydrocarbonaceous feeds contain hydrogen as well as carbon, and typically contain various amounts sulfur compounds and nitrogen compounds, it is highly unlikely that the carbon atom content of the feed would ever be 99% as assumed by the Examiner. Note, for example, the feed employed in Examples I to III of Yoo contained 85.80 wt% carbon (see col. 9, line 24).

For all these reasons it is submitted that the Examiner's calculated oxygen-to-carbon ratio is fatally flawed and not based on the actual teachings of Yoo. The fact that the Examiner could not find a disclosure of an oxygen-to-carbon ratio of below 0.15 in any of the cited references, and had to resort to a calculated value based on another ratio (oxygen to sulfur), is itself evidence of the unobviousness of the oxygen-to-carbon ratio limitations in the present claims.

In response to the comments made by the Examiner in paragraph 32 on page 20 of the subject Office action, Applicants submit that one skilled in the art would know what is meant by the oxygen-to-carbon ratio of the feed mixture as this term is defined on page 6 of the specification. It is the ratio of oxygen in the form of O₂ molecules to carbon atoms present in the feedstock. It does not depend on the type of hydrocarbons in the feed, i.e., methane, ethane, propane, etc. Instead, it depends on the ratio of O₂ molecules to carbon atoms present per unit of feedstock. That the type of hydrocarbons in the feedstock does not determine the ratio can be seen by referring to Table 1 and Table 2 on pages 10 and 11 of the present specification. In each of these Tables the feedstock was methane. However, the O₂:C ratios varied from 0.04 to 0.07 in

Table 1 and from 0.02 to 0.05 in Table 2. Thus, it can be seen that the oxygen-to-carbon ratio in the feed is adjusted by increasing or decreasing the amount of oxygen relative to the carbon atoms per unit of feed. It is not dependent on the specific type of hydrocarbon in the feed, and is not determined by adding up the carbon numbers of the feed as the Examiner appears to have done in paragraph 32 of the subject Office action.

I. (h) Mahadev et al (WO 92/20621) (hereafter “Mahadev”)

Mahadev discloses a process for the removal of hydrogen sulfide and other sulfur compounds from sour natural gas and other fluid streams, and the conversion of the sulfur therein to elemental sulfur (page 1, lines 9-19). The Mahadev process is a two-step process involving the absorption of sulphur compounds from a fluid stream and then the subsequent decomposition of such compounds into elemental sulfur. (See page 3, line 16-20). This is a significantly different process from the process in Frame. The Mahadev catalyst is also significantly different from the two component Group VIIB metal and Group VIII metal phthalocyanine catalyst system employed by Frame. The Mahadev catalyst is an alkali metal sulphide and sulphide or selenide of metal having polyvalent and/or amphoteric character on a microporous support. See e.g., Abstract; page 3, lines 28-31; claim 7. This catalyst is not even remotely similar to the two-component metal phthalocyanine catalyst system employed by Frame.

While Mahadev discloses a feed stream of natural gas containing up to 10 wt% hydrogen sulfide, and that the adsorptive capacity of the catalyst remains unchanged for feeds with less than 10 wt% hydrogen sulfide, as stated in the on page 4 of the subject Office action, this would not make it obvious to one of ordinary skill in the art to modify the process of Frame to include a natural gas stream containing up to 10 wt% hydrogen sulfide “in order to preserve the adsorptive capacity of the catalyst” as contended on page 5 of the subject Office action. The two-component metal phthalocyanine catalyst system employed by Frame is an oxidation catalyst that operates in a medium having a pH of from 8 to 14. It does not operate by adsorption. Therefore, it would not be obvious to modify the process of Frame, which uses a two-component metal phthalocyanine catalyst system, to oxidize up to 10 wt% hydrogen sulfide in natural gas “in order to preserve the adsorptive capacity of the catalyst”.

However, even assuming arguendo that it would be obvious to modify the process in Frame to treat gases containing high concentrations of hydrogen sulfide, this still would not

result in the presently claimed process, since Frame only oxidizes hydrogen sulfide to elemental sulfur; not to sulfur dioxide as specified in the present claims. (See discussion in Section I. (e) above.)

With respect to claim 20, the Examiner cites Mahadev on page 6 of the subject Office action for its disclosure of a flue gas having a concentration of sulfur dioxide in the range of 1000 ppm to 2000 ppm. Applicants do not understand the relevance of this latter disclosure to claim 20, since claim 20 specifies the feedstock to be a liquid hydrocarbonaceous feedstock containing at the most 1000 ppmv sulfur. Flue gas is obviously not a liquid as required by claim 20, and is not a hydrocarbonaceous feedstock as also required by claim 20.

Beyond the disclosure that natural gas can have a hydrogen sulfide concentration of up to 10 %, which Applicant acknowledges, Mahadev appears to have little relevance to the presently claimed selective oxidation process. Mahadev does not teach or reasonably suggest a catalyst similar to that employed in Applicants' selective oxidation process, does not teach or reasonably suggest a feed mixture of a hydrocarbonaceous feedstock and a molecular-oxygen containing gas having an oxygen-to-carbon ratio of below 0.15, which is important to achieving selective oxidation of sulfur compounds with no or minimal oxidation of hydrocarbon compounds.

In paragraph 34 of the subject Office action, it is stated that Madadev is not limited to the treatment of flue gas, but that "[his catalyst]" is suitable for removing organic sulfur compounds from a mixture of more complex natural gas components including gaseous and liquid phase. In their previous response and in the above paragraph, Applicants were merely questioning the relevance of the portion of Madadev cited in the previous Office action and repeated in this Office action, which had to do with flue gas, to claim 20 which has to do with sulfur concentrations in a liquid hydrocarbonaceous feedstock. Regardless of whether Madadev's catalyst is applicable to flue gas or mixtures of more complex natural gas components, the fact remains that the catalyst disclosed in Madahev is very different from Frame's two component Group VIIB and Group VIII metal phthalocyanine catalyst system and also very different from Applicants' supported group VIII noble metal catalyst system. In addition, Mahadev does not disclose the oxygen-to-carbon ratio limitations recited in the present claims.

I. (i) Mackrodt et al (US 5,137,862) (hereafter “Mackrodt”)

Mackrodt discloses an oxidation process comprising reacting a feedstock with an oxygen-containing gas in the presence of an oxidic catalyst under conditions such that the catalyst attains a temperature of at least 1000 °C, wherein the catalyst is essentially free from elements, or compounds thereof, of Group VIII of the periodic table (col. 3, lines 17-23).

While Mackrodt does teach that yttria may be incorporated into zirconia supports as a means as stabilizing zirconia against phase changes, Mackrodt also teaches that the catalyst employed in the disclosed oxidation process must be essentially free from Group VIII metals, and that the oxidation process should be conducted under conditions that the catalyst attains a temperature of at least 1,000 °C. Thus, Mackrodt, taken as a whole, teaches away from Applicants’ process in which a Group VIII noble metal is employed as the essential catalytic component, and which process is conducted at temperatures below 500 °C.

It is also noted that the processes in which Mackrodt teaches its catalysts can be used are basically partial oxidation or catalytic combustion processes in which gaseous hydrocarbons feedstock is oxidized (col. 7, lines 5-30). This is in marked contrast to Applicants’ selective oxidation process in which sulfur compounds are selectively oxidized to sulfur dioxide with no or minimal oxidation of hydrocarbons. This important feature of Applicants’ process is expressly recited in the present claims. Since Mackrodt is interested in maximizing combustion or oxidation of the hydrocarbon feedstock, the oxygen-to-carbon ratios in Mackrodt will be much higher than the below 0.15 ratio specified in the present claims. Therefore, Mackrodt adds nothing to overcome the deficiency of the primary Frame reference in failing to teach the oxygen-to-carbon ratios recited in the present claims.

I. (j) Evidence to Establish the Criticality of the Group VIII Noble Metal Concentration in the Present Catalyst Compositions is Not Required in the Present Circumstances.

On page 5 of the subject Office action, the examiner takes the position that the metals concentration range recited in the claims does not support the patentability of the claimed subject matter, since MPEP § 2144.05 (II)(A) requires evidence of the criticality of a claimed concentration range in order to support patentability. The MPEP section cited and relied upon by the Examiner to support this proposition is not properly applicable in the instant case. The MPEP section addresses situations involving optimization of ranges within known prior art ranges that

may be determined through routine experimentation. This, however, is not the situation with the instant claims, which are directed to a process for the selective oxidation of sulphur in hydrocarbon feedstock by the use of a specifically defined catalyst composition that has a significantly different composition than those used in the prior art for this purpose. Neither Frame, Yoo, Mahadev nor Mackrodt disclose concentration ranges for catalysts which selectively oxidize various sulfur compounds to sulfur dioxide, with no or minimal oxidation of non-sulfur containing hydrocarbonaceous compounds. Under these circumstances, Applicants are not required to establish the criticality of the recited metals concentration range in order to establish patentability.

II. The Rejection of Claims 46, 47, 49, 50, and 70-74 and 80-84 under 35 U.S.C. §103(a) as Being Unpatentable over Frame (US 3,978,137) in View of Yoo (US 3,945,914), Mahadev (WO 92/20621), and Madgavkar (US 4,382,912), to the extent it applies to the Amended Claims, is Respectfully Traversed

II. (a) Neither Frame nor Yoo Teach or Reasonably Suggest a Gaseous Feed Mixture Having the Oxygen-to-Carbon Ratios Recited in the Present Claims

As discussed in Sections I. (g) above, neither Frame nor Yoo suggest a gaseous feed mixture having the oxygen-to-carbon ratios recited in the present claims.

II. (b) Madgavkar et al (US 4,382,912) (hereafter “Madgavkar”)

Madgavkar discloses a process for purifying a hydrogen sulfide-containing carbon dioxide stream by selective oxidation of the hydrogen sulfide to sulfur dioxide without concomitantly causing the reaction of carbon dioxide to form impurities such as carbonyl sulfide and carbon disulfide and undesirable hydrocarbon reaction products (abstract and col. 1, line 66 to col. 2, line 5). The resulting sulfur-containing carbon dioxide gas stream is then treated to remove sulfur dioxide so as to recover a sulfur free carbon dioxide stream, which can be injected into a petroleum formation for improving oil recovery (col. 2, lines 15-20). The catalyst employed by Madgavkar is an iron catalyst, preferably Fe_2O_3 , supported on an inert rigid porous refractory ceramic honeycomb support (col. 3, lines 37-40).

While Madgavkar does teach Fercalloy as a support material, the overall catalyst employed by Madgavkar is totally unlike the Group VIII noble metal catalyst employed by Frame or employed by Applicants in the present selective oxidation process. The feedstream

treated in Madgavkar (a hydrogen sulfide containing carbon dioxide gas stream), is also different from the feedstream in Frame or the sulfur containing hydrocarbonaceous feedstock treated in the present selective oxidation process. Because of these differences it would not be obvious to use the Fercalloy support disclosed in Madgavkar in the two-component Group VIIB metal phthalocyanine and a Group VIII metal phthalocyanine catalyst system disclosed in Frame.

II. (c) Neither Mahadev nor Madgavkar Overcome the Deficiencies of Frame and Yoo Discussed in Sections II. (a) and II. (b) above Regarding the Catalyst and the Oxygen-to-Carbon Ratios Employed in the Presently Claimed Process.

Neither Mahadev nor Madgavkar disclose a catalyst that consists essentially of a catalytically active group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof. As discussed in Section I. (h), above, Mahadev uses an alkali metal sulphide and sulphide or selenide of metal(s) having polyvalent and/or amphoteric character on a microporous support to absorb sulfur compounds. As discussed in Section II. (b), above, Madgavkar employs an iron catalyst, preferably Fe_2O_3 , supported on a ceramic honeycomb support, to oxidize hydrogen sulfide in a hydrogen sulfide-containing carbon dioxide gas stream (Madgavkar, abstract and col. 2, lines 5-14). Thus, neither Mahadev nor Madgavkar cure the deficiency of Frame in not teaching a catalyst that consists essentially of a catalytically active Group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof, which is a limitation in each of claims 46, 47, 49, 50, 70-74, and 80-84, either expressly or through dependency.

In addition, neither Mahadev nor Madgavkar teaches or reasonably suggests a feed mixture of a hydrocarbonaceous feedstock and a molecular-oxygen containing gas having an oxygen-to-carbon ratio of below 0.15. Mahadev removes sulfur compounds such as hydrogen sulfide and sulfur oxides from fluid streams, such as flue gas, by absorption. Hence, there is no feed mixture of a hydrocarbonaceous feedstock and a molecular-oxygen containing gas in Mahadev. Consequently, there is no teaching in Mahadev regarding an oxygen-to-carbon ratio of such a feed gas mixture. Oxygen is not introduced in Mahadev until the second step (the regeneration step), in which the sulfur compounds absorbed in the first step are decomposed to elemental sulfur.

The process disclosed in Madgavkar involves removing hydrogen sulfide from a hydrogen-sulfide-containing carbon dioxide gas stream. Hence, Madgavkar does not teach a feed

mixture of a hydrocarbonaceous feedstock and a molecular-oxygen containing gas having an oxygen-to-carbon ratio below 0.015. (Carbon dioxide is not a hydrocarbonaceous feedstock.)

In summary, neither Frame, Yoo, Mahadev nor Madgavkar teach or reasonably suggest a selective oxidation catalyst that “consists essentially of a catalytically active group VIII noble metal selected from the group consisting of platinum, rhodium, iridium and combinations of two or more thereof”, or a “feed mixture of a hydrocarbonaceous feedstock and a molecular-oxygen containing gas having an oxygen-to-carbon ratio of below 0.15. Therefore, claims 46, 47, 49, 50, 70-74, and 80-84 are patentable over the cited combination of references.

III. The Rejection of Claims 1, 2, 9, 11-21 and 24 Under 35 U.S.C. §103(a) as Being Unpatentable over Srinivas (US 7,060,233) in view of Mackrodt (US 5,137,862), to the Extent it Applies to the Amended Claims, is Respectfully Traversed.

III. (a) Srinivas et al (US 7,060,233) (“Srinivas”)

Srinivas concerns a process for the removal of hydrogen sulfide and other sulfur compounds and mercury from gas streams, particularly natural gas streams and synthesis gas streams containing mercury (col. 3, lines 16-20). The process disclosed in Srinivas converts hydrogen sulfide in such gas streams at least in part to elemental sulfur which is condensed and removed from the gas stream (col. 3, lines 22-25). Elemental mercury present in such streams in which sulfur is generated is converted to mercuric sulfide in the presence of sulfur and is also removed in the sulfur condenser (col. 3, lines 25-28).

While Srinivas does teach that the disclosed process can be used to generate a mixture of sulfur and sulfur dioxide, Srinivas requires that at least part of the hydrogen sulfide must be converted into elemental sulfur in order that the sulfur can react with and remove mercury, which is an essential purpose of the process in Srinivas. In marked contrast, Applicants’ process is designed to selectively oxidize hydrogen sulfide and other sulfur compounds, including difficult to remove heterocyclic sulfur compounds such as thiophenes, directly to sulfur dioxide. The formation of elemental sulfur in Applicant’s process is undesirable, as it would be detrimental to processing equipment and may result in deactivation of the group VIII noble metal catalyst employed in Applicants’ selective oxidation process.

The selective oxidation of hydrogen sulfide and sulfur compounds directly to sulfur dioxide is accomplished in Applicants’ process by employing a particular defined catalyst and

particular operating conditions including use of a feed mixture having an oxygen-to-carbon ratio of below 0.15, preferably below 0.10. As acknowledged on page 10 of the subject Office action, Srinivas does not explicitly disclose the limitation in present claims that the feed mixture has an oxygen-to-carbon ratio of below 0.10. The Examiner attempts to overcome this deficiency by claiming Srinivas inherently discloses a feed mixture having a oxygen-to-carbon ration below 0.10, stating on page 10 of the subject Office action that: “In this regard Srinivas discloses wherein the oxidizing gas is O₂ (see Srinivas, col. 5, lines 4-15) and the feed may have at least 43 carbon atoms present therein (see Srinivas Table 2)”. Applicants have reviewed Table 2 of Srinivas and find it sets forth the composition of a methane rich natural gas. Applicants’ are uncertain how in Examiner concluded from Table 2 that “the feed may have at least 43 carbon atoms present therein”. It is also unclear how from this information it was concluded that the feed mixture inherently had an oxygen-to-carbon ratio of below 0.10.

As discussed in Section I. (g) above, the oxygen-to-carbon ratio in the feedstock does not depend on the type of hydrocarbons in the feed, i.e., methane, ethane, propane, etc. Instead, it depends on the ratio of O₂ molecules to carbon atoms present per unit of feedstock. The oxygen-to-carbon ratio in the feed is ratio of oxygen in the form of O₂ to carbon atoms present in the feed mixture. It is not dependent on, nor can it be calculated from, the carbon number of the various hydrocarbons in the feed.

It is respectfully submitted that oxygen-to-carbon ratios below 0.10 are not taught by Srinivas, and that the data in Table 2 of Srinivas does not support the contention that the feed mixture in Srinivas would inherently have an oxygen-to- carbon ratio below 0.10. Since Srinivas requires that at least part of the hydrogen sulfide be converted to sulfur, and uses a different preferred catalyst than that employed by Applicants (this will be discussed in greater detail below), there is no reasonable basis for concluding that Srinivas must inherently have an oxygen-to- carbon ratio below 0.10.

Regarding the catalyst disclosures in Srinivas, Applicants acknowledge that Srinivas in col. 12, lines 56-59, cited in the subject Office action, discloses Rh (rhodium), which is one of the catalytically active group VIII noble metals which can be employed in the present selective oxidation process. However, Rh is disclosed as one of a large number of higher oxidation activity metal oxides from various groups on the periodic table. Srinivas goes on to teach that preferred higher activity metal oxides are those of Mo, Nb, Fe, Cr, Cu and Co (col. 12, lines 63-65).

Regarding supports, Srinivas does teach zirconia as one of many possible supports, but does not teach zirconia stabilized or partially stabilized with yttria, as acknowledged on page 10 of the subject Office action. In addition, Srinivas does not teach use of a performance enhancing inorganic cation as claimed in claims 65 and 75, coating the catalyst carrier with a zirconia paint comprising zirconium oxide stabilized with CaO, as claimed in claims 11 and 85, or use of a catalyst carrier comprising a non-refractory bulk material having an oxidizing surface layer consisting of alumina or zirconia. Thus, Srinivas does not disclose the specifically claimed selective oxidation catalysts employed in the present process with sufficient specificity to render these catalysts prima facie obvious, and does not disclose the oxygen-to- carbon ratios recited in the present claims.

III. (b) It would Not be Obvious Based on the Teachings of Mackrodt, to Employ Yttria to Stabilize Zirconia in the Process of Srinivas Because of the Different Catalysts and Conditions Involved

As discussed in Section I (i) above, while Mackrodt teaches in column 4, lines 2-7, that yttria may be incorporated into zirconia supports as a means as stabilizing zirconia against phase changes, Mackrodt also teaches that the catalyst employed in the disclosed oxidation process must be essentially free from Group VIII metals, and that the oxidation process should be conducted under conditions that the catalyst attains a temperature of at least 1,000 °C (*see* col. 3, lines 17-23). Thus, Mackrodt, taken as a whole, teaches away from Applicants' process in which a Group VIII noble metal is employed as the essential catalytic component, and which process is conducted at temperatures below 500 °C. Srinivas also teaches a selective oxidation process conducted at temperatures of below 500 °C. Therefore, one skilled in the art would not be motivated by Mackrodt to incorporate the yttria into catalysts of Srinivas to stabilize zirconia, as stated in the subject Office action, since there is no teaching in any of the cited references that stabilization of zirconia is required at the lower temperatures, i.e., below 500 °C, utilized by Srinivas. Mackrodt teaches stabilization is required at temperatures of at least 1000 °C., Mackrodt teaches the oxidation catalysts of the disclosed type should be essentially free of Group VIII metals, which is an essential component of the selective oxidation catalysts employed in Applicants' process for selectively oxidizing sulfur compounds to SO₂.

While both Srinivas and Mackrodt may be directed in part to the use of zirconia supported oxidation catalysts as stated on page 10 of the subject Office action, the respective processes and

operating conditions are quite different (selective oxidation at low temperatures leading to simultaneous removal of sulfur and mercury vs. catalytic combustion at high temperatures in which hydrocarbons are intentionally oxidized). Therefore, it is not at all clear that modifying the process of Srinivas in accordance with the teachings of Mackrodt, would have a reasonable expectation of success as proposed at the bottom of page 10 of the subject Office action.

III. (c) Mackrodt Does Not Overcome the Deficiency in Srinivas in Failing to Teach the Oxygen-to-Carbon Ratios Recited in the Present Claims

Since Mackrodt is interested in maximizing combustion or oxidation of the hydrocarbon feedstock as discussed in Section I. (i) above, the oxygen-to-carbon ratios in Mackrodt will be much higher than the below 0.15 oxygen-to-carbon ratio specified in the present claims. Therefore, Mackrodt adds nothing to overcome the deficiency of Srinivas pointed out above, in failing to teach the oxygen-to-carbon ratios recited in the present claims.

IV. The Rejection of Claims 25, 26, 30, and 33-44 Under 35 U.S.C. §103(a) as Being Unpatentable over Srinivas (US 7,060,233) in view of Mackrodt (US 5,137,862) and D'Souza (US 4,233,276), to the Extent it applies to the Amended Claims, is Respectfully Traversed.

IV. (a) Neither Srinivas nor Mackrodt Disclose the Oxygen-to-Carbon Ratio Limitations Recited in the Present Claims

As discussed in Sections III. (a) and III. (c) above, neither Srinivas nor Mackrodt expressly or inherently disclose the oxygen-to-carbon ratio recited in claims 25, 26, and through dependency in claims 30, and 33-44.

IV. (b) D'Souza et al (US 4,233,276) (hereafter "D'Souza") Does Not Overcome the Deficiencies of Srinivas and Mackrodt

D'Souza discloses a process for removing oxidizable sulfur compounds from waste streams, preferably from a Claus plant, by oxidizing the waste gas with molecular oxygen to convert the oxidizable sulfur compounds and free sulfur to sulfur dioxide or sulfur trioxide. The sulfur dioxide and sulfur trioxide are subsequently removed using a metal oxide adsorbent. The metal oxide adsorbent is subsequently regenerated with a hydrocarbon in the presence of a hydrocracking catalyst (D'Souza, col. 3, line 66 to col.4, line 10).

D'Souza is apparently cited for its teaching that sulfur dioxides and trioxides can be removed from an oxidized stream using copper oxide or barium oxide, which Applicants acknowledge. However, Applicants are not relying on the removal of sulfur dioxide using a metal oxide adsorbent for the patentability of claims 25, 26, 30 and 33-34. Instead, Applicants are relying on the fact that neither D'Souza (nor Srinivas nor Mackrodt) teach or reasonably suggest a selective oxidation process employing a feed mixture of a hydrocarbonaceous feedstock and a molecular oxygen containing gas having an oxygen-to-carbon ratio of below 0.15. There is no teaching or suggestion in D'Souza that the waste gas, such as a Claus plant tail gas, oxidized in step (a) is a hydrocarbonaceous feedstock, and, therefore, certainly no teaching suggestion that the feed mixture used in the oxidizing step should have an oxygen-to-carbon ratio below 0.15.

Therefore, D'Souza, while disclosing the use of copper and barium oxide adsorbents for removing sulfur dioxide, does not cure the basic deficiency of Srinivas and Mackrodt in failing to teach or reasonably suggest a feed mixture having an oxygen-to-carbon ratio of below 0.15.

Accordingly, claims 25, 26, 30 and 33-34 are patentable over the cited combination of references.

V. The Rejection of Claims 45, 48, 65-69, and 75-79 Under 35 U.S.C. §103(a) as Being Unpatentable over Srinivas (US 7,060,233) in view of Mackrodt (US 5,137,862) and Wachs (US 7,374,666), to the Extent it applies to the Amended Claims, is Respectfully Traversed.

V. (a) Neither Srinivas nor Mackrodt Disclose the Oxygen-To-Carbon Ratio Limitations Recited in the Present Claims

As discussed in Section III. (a) and III. (c) above, neither Srinivas nor Mackrodt expressly or inherently disclosed the oxygen-to-carbon ratio recited in claims 45, 48, 52, and through dependency in claims 65-69 and 75-79.

V. (b) Wachs (US 7,374,666) (hereafter "Wachs") Does Not Overcome the Deficiencies of Srinivas and Mackrodt Regarding and Oxygen-to-Carbon Ratio Recited in the Claims

Wachs discloses a process for desulfurizing a hydrocarbon stream containing heterocyclic sulfur compounds which comprises contacting the heterocyclic sulfur compounds in gas phase with a supported metal oxide catalyst or a bulk metal oxide catalyst to convert at least part of the

heterocyclic sulfur compounds to oxygenated products (Abstract, col. 5, lines 33-40). The oxygenated products may include maleic anhydride, phenol, benzyl aldehyde and benzoic acid and like (col. 15, lines 30-34). The metal oxide catalyst can be based on various metals including titanium, zirconium, molybdenum, rhenium, vanadium, chromium, etc. (col. 5, lines 40-56). Suitable supports for the metal oxide catalysts include titania, silica, zirconia, alumina, ceria, magnesia, etc. (col. 5, lines 48-56). There is no disclosure in Wachs of a group VIII noble metal catalyst of the type employed in present process.

Wachs is apparently cited for its teaching that cerium and zirconium are useful adjuvants that may be added to an oxidation catalyst. However the oxidation catalyst disclosed in Wachs does not consist essentially of a group VIII noble metal. Moreover, there is also no disclosure in Wachs as to the oxygen-to-carbon ratio of the feed mixture. Therefore, Wachs does not teach or suggest a selective oxidation catalysts consisting essentially of a mixture of rhodium, iridium, zirconium and cerium as recited in amended claim 45, or a mixture of iridium, zirconium and cerium as recited in amended claim 48, and does not overcome the deficiencies of Srinivas and Mackrodt regarding their failure to teach the oxygen-to-carbon ratios recited in these claims. The dependency of claims 75-79 have been changed to claim 49 which requires a catalyst carrier comprising a non-refractory oxide bulk material having an oxidizing surface layer selected from the group consisting of alumina and zirconia. The specified catalyst carrier is not taught or suggested in any of the cited references.

VI. The Rejection of Claims 51 and 85-89 Under 35 U.S.C. §103(a) as Being Unpatentable over Srinivas (US 7,060,233) in view of Mackrodt (US 5,137,862), D'Souza (US 4,233,276), and Wachs (US 7,374,666), to the Extent it applies to the Amended Claims, is Respectfully Traversed.

As discussed in Sections V. (a), V. (b) and IV. (b) above, neither Srinivas, Mackrodt, D'Souza, nor Wachs expressly or inherently disclose the oxygen-to-carbon ratio in the feed mixture as recited in claims 51 and 89, and through dependency in claims 85-88. Therefore, claims 51 and 85-89 are patentable over the cited references at least on the basis of the oxygen-to-carbon ratio limitation present in these claims.

VII. The Rejection of Claims 46, 47, 49, 50, and 80-84 Under 35 U.S.C. §103(a) as Being Unpatentable over Srinivas (US 7,060,233) in view of Madgavkar (US 4,382,912), to the Extent it applies to the Amended Claims, is Respectfully Traversed.

As discussed in Section III. (a) above, Srinivas does not disclose or inherently achieve an oxygen-to-carbon ratio in the feed mixture of below 0.15 or 0.10 as recited in the present claims.

As discussed in Section II. (c) above, Madgavkar also does not disclose a feed mixture having an oxygen-to-carbon ratio below 0.15, or 0.10. Therefore, claims 46, 47, 49, 50, and 80-84 are patentable over the cited references at least on the basis of the oxygen-to-carbon ratio limitation present in these claims.

VIII. The Rejection of Claims 52, 53, and 90-94 Under 35 U.S.C. §103(a) as Being Unpatentable over Srinivas (US 7,060,233) in view of Madgavkar (US 4,382,912), and D'Souza (US 4,233,276), to the Extent it applies to the Amended Claims, is Respectfully Traversed.

As discussed in Sections III. (a), II. (c) and IV. (b) above, neither Srinivas, Madgavkar, nor D'Souza, expressly or inherently disclose the oxygen-to-carbon ratio in the feed as recited in claims 51 and 89, and through dependency in claims 85-88. Therefore, claims 51 and 85-89 are patentable over the cited references at least on the basis of the oxygen-to-carbon ratio limitation present in these claims.

Conclusion

For all the above reasons and in view of the amendments, it is respectfully submitted that claims 1-2, 9, 11-21, 24-26, 30, 33-53 and 65-94 are patentable over the cited references. Accordingly, their early allowance is respectfully requested.

Respectfully submitted,

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